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COST OF TRANSPORTATION ON RAILROADS. BY CHARLES ELLET, JR. CIV. ENG.

(Continued from page 349.)

REPAIRS OF ENGINES AND CARS.

It is the custom of many companies to publish the cost of repairs of their cars and engines in a single item, so as to make it impossible for the reader to determine, from their accounts, what portion of the bill was created by the engines, or the difference between the repairs due to different sorts of cars; but still an industrious investigation of the subject gives us facts enough to estimate these separate items for ordinary cases, with all desirable accuracy. I have stated in a former paper that the repairs of burthen cars are worth, on the average, 4½ mills per ton per mile; and that the repairs of the engines averaged, during the year 1842, *seven* cents per mile run. I have also observed that the repairs of passenger cars vary from three-fourths of a mill to a mill and a half, and sometimes exceed 2 mills per passenger per mile. If these facts—all of which enter into the formula which I have offered for the determination of the aggregate annual expenses of a railroad company—be well established, they will not only stand the test of trial for the aggregate, but they will apply in detail. Not only should the formula for determining the aggregate expenses be correct, and correspond with actual results—as we have seen—but the separate items of which it is composed, must, likewise, bear the test, and give results in agreement with the average results of experience.

It is not pretended that a formula could be offered which would show the exact cost of every item of every company for every year—because the actual expenditures due to each item fluctuate from year to year; but it is maintained that these fluctuations are above and below a certain average line, from which they may depart towards either side for a certain time, but to which, and beyond which, on the opposite side, they are as sure to come as the pendulum is sure to approach the vertical in its vibrations. Although it was not my intention to enter so minutely into these details, probably

more confidence will be yielded to my statements when the data on which they are founded are presented. These data, for the repairs of engines, are exhibited in the following

TABLE.

Name of roads.	Year.	Miles run by engines.	Cost of repairs of engines.	Repairs per mile run.	Remarks.
			Dollars.	*Cents.*	
Phil. Wilm. & Balt.	1842	177,859	17,071	9·9	Old road.
Western road,	1842	397,295	24,177	6·1	New road.
Georgia road,	1842	152,873	10,155*	6·7	Ordin'y & extr'ny rep's & improv'ts.
Baltimore & Susq.,	1842	128,349	7,193	5·6	New road.
Utica & Schenec.,	1842	150,000	10,346	6·9	Passenger business.
Baltimore & Ohio,	1841	299,617	20,640	7·0	Old roads in good condition.
Baltimore & Wash.	1842	95,817	7,973	7·2	
Philad. & Columb.,	1842	261,744	21,915	8·4	Genr'ly fre't. bus'ns.
Boston & Provid.,	1842	112,805	7,257	6·5	Old roads in good condition.
Baltimore & Ohio,	1843	509,765	35,941	7·0	
Wash. & Baltimore,	1843	96,716	6,714	7.0	
		2,382,840	169,380	Av7·1	

This table exhibits the cost of repairs of engines which have traversed a space of 2,382,840 miles; and shows that the average is within one-tenth of a cent, per mile run, of the mean value at which I had stated it. It is my impression, however, that the average on these same roads will be greater for the year 1843.

Now, if we call N the number of miles travelled by the locomotive engines; T the number of tons of freight carried one mile; and P the number of passengers carried one mile, the average aggregate cost of repairs of passenger and burthen cars, and locomotive engines, will be shown, very nearly, by the formula,

$$\frac{7N}{100}+\frac{4.5T}{1000}+\frac{P}{1000}.$$

By expressing the cost of repairs in this way, we are able to determine, at once, the expenses of repairs for an entire train composed of either description of cars, or of both sorts, combined in any proportions.

Although this, and all my other, estimates might be much strengthened, by bringing forward facts resulting from former experience, I prefer, with one or two exceptions, to limit my examples, on this occasion, to those works of which I have obtained authentic information for the year 1842. Of course, I exclude those lines which have been so recently completed, as to require no repairs at all for cars.

The following table presents the number of miles run by locomotive engines, and the number of tons and passengers carried one mile on eight railroads for the year 1842, and two for 1843—which have been recently

* This company have added to the usual division of their expenses into ordinary and extraordinary repairs, the new classification of "improvements to engines;" not being able to conceive that a small stock of engines could run 153,000 miles, and be materially improved by it, I regard these "improvements" as expenses.

published;—and in the two last columns will be seen the actual expenses of repairs of cars and engines, and the expenses of the same computed by the formula.

TABLE.

Name of road.	Year.	Miles run by engines.	Tons carried one mile.	Passengers carried one mile.	Actual cost of repairs.	Computed cost of repairs.
					Dolls.	*Dolls.*
Petersburg road,	1842	131,160	1,342,000	976,000	16,513	16,196
Boston and Providence,	1842	120,000	890,400	4,919,418	13,506	17,326
Baltimore and Ohio,	1841	299,617	3,647,093	2,495,911	45,534	39,881
Baltimore and Ohio,	1842	334,519	3,985,425	2,738,779	44,568	44,189
Baltimore and Ohio,	1843	509,765	7,109,310	6,062,455	62,862	73,738
Baltimore and Wash.,	1843	96,716	805,429	2,646,719	17,453	14,801
Baltimore and Susque.,	1842	128,349	1,610,000	1,165,000	13,370	17,390
Baltimore and Wash.,	1842	95,817	877,138	3,188,948	17,053	13,864
Utica and Schenectady,	1842	150,000		8,413,704	18,842	18,914
Boston and Lowell,	1842	143,607	2,442,102	4,675,294	28,816	25,716
Georgia road,	1842	152,873	1,475,000	1,770,000	19,899	19,107

On inspecting this list we will observe that the actual charges on some of the roads are a little above, and on others a little below, the indications of the formula—but that the deviations are in no instance too wide to render the rule, as far as it goes, a safe test of the value of an investment. The actual* cost on the Baltimore and Ohio railroad falls considerably below the computed cost for the year 1843. In 1842 the agreement was very close, and in 1841 the result was nearly as much above as that of 1843 is below the rule. Indeed, in 1841 the sum of $9,766 was expended for *new* burthen and passenger cars, in addition to the $45,534 charged to repairs of cars and engines. The aggregate expenses for repairs of cars and engines, on that work, for the three years amounted to $152,964—and the expenses calculated by the formula to $157,808. If we add the sum paid for *new cars*, to the actual cost of repairs, the actual expenses, for the three years, will be $162,730, or 3 per cent. above the computed expenses.

The formula simply exhibits what it is intended to show—the average for a succession of years. I do not include the Boston and Worcester road in this table, because the result on that work is entirely anomalous. For previous years the agreement between the calculation and expenses was sufficiently close; but in 1842 there was a material increase of business, an extraordinary reduction in the expense of repairing the cars and engines, and a simultaneous augmentation of the capital—or charge for construction—of $390,000. I am obliged to suppose that new cars and engines were added to the line, and that a portion of the business was performed by new stock.*

We may now pass to another very important division of railroad expenses, which are usually, though very improperly, denominated "extraordinary expenses." I refer chiefly to the

* The cost of repairs of locomotive engines for this road, for the year 1841, was 9 1-2 cents per mile run, and in a space of seven years, from 1835 to 1841 inclusive, the engines performed an aggregate distance of 850,809 miles, at an aggregate cost of $84,183; or within a fraction of 10 cents per mile run. The repairs of cars are fluctuating, but the average is in accordance with the formula. This road is not an exception to the rule, though the formula does not apply for the year 1842.

WEAR OF IRON RAILS.

There is, perhaps, no subject of interest to the engineer which has attracted less serious attention, or has been more vaguely and indefinitely considered, than the wear of railroad iron. Instead of attempting to find some correct and rational measure of this wear, the public, and in a great measure, the profession also, have persisted in regarding the visible destruction of the iron on roads which have been some years in operation, as a consequence of the inferior quality of the particular specimen, or of the inadequate strength of the particular pattern. It is the custom to say that the mashed and splintered iron of the Camden and Amboy, and Columbia roads was bad; but no argument has ever been adduced to show that good iron, in the same situation, and subjected to the same sort of treatment, would do better.

So long as railroads happened to occupy positions where they would be used for the mere conveyance of the travel, and a few thousand tons of goods, between adjacent cities, the durability of iron was a question of subordinate interest. An engineer could be satisfied that his rail would last 10 or 20, or 30 years, and could generally count on a sufficient increase of business consequent on the increase of population, to compensate for its destruction in that space of time. But railroads are now projected to take the place of important canals, and to furnish the means of transport for the heavy products of the earth at exceeding low rates. The question assumes, therefore, another aspect. The trade of the Erie canal in New York, and of the Schuylkill Navigation in Pennsylvania, may be estimated at 800,000 to 1,000,000 tons per annum; and there is no railroad in the United States worked by steam power, which accommodates more than the one-ninth, or one-tenth, of this amount, with the exception of the Reading railroad, which has not yet been long enough in operation to yield any useful practical results.

The common half-inch flat bar, under ordinary circumstances, is adequate to the transportation of about 150,000 tons of freight. Such a bar on the Petersburg road, where the freight amounts to some 25,000 tons, would resist the wear of six years' business; but if one year's trade of the Schuylkill canal were poured along it, the iron part of the track would need entire renewal *six times in one year.*

The same remark is applicable to any of the same sort of wooden roads in the country. They would all bear about 150,000 tons net, drawn at the usual speed of ordinary freight engines, but would be completely destroyed by about *five weeks' business* of the Schuylkill Navigation, in the season of active trade.

It must be admitted that we have not yet sufficient data for estimating, with entire certainty, the probable durability of many varieties of rails. We have, however, data sufficient, if we use it properly, to make a much nearer approximation than is generally supposed to be practicable. The durability of the half inch plate rail can be determined with all desirable

accuracy, and we can judge from analogies, which the problem presents, the probable wear of other patterns. Great errors have been committed in the consideration of this subject, by overlooking the fact that the progress of the wear is rarely ascertained, or, in the least, appreciated, until the rail is destroyed. The *annual* charge for iron is very small, because, in general, the track does not appear to give way until it is nearly unfit for use. When repairs really commence, the destruction is so far advanced that the iron must be renewed; and if the directors assert, as they usually do, in their next report to the stockholders, that experience has shown that the original iron was very bad, and has all been crushed, the explanation is satisfactory, and the cost of the new iron is forthwith charged to the account of construction.

We accordingly find, in looking through the reports of railroad companies, that the average annual increase of capital, generally exceeds the dividends even of the most successful enterprises: and *there is not now to be found in the country a single road which has renewed its iron out of the proceeds of transportation.* While the trade continues to be small, and this extraordinary outlay is needed but once every six or eight years, the self-deception can be practised with considerable success. But there are now works constructed which are intended for a very great business, and and which will reduce the extraordinary charge for renewal of iron down to a very ordinary circumstance. The Reading railroad is contemplated for the conveyance of the present trade of the Schuylkill canal — from eight to nine hundred thousand—and which will very soon reach one million of tons—and should the experiment succeed, *the cost of iron will be more than equal to the entire renewal of a single track every year.* The question of wear, is, therefore, of immense importance, and can no longer be lightly disposed of by companies of this class.

This, as every other item of railroad expenses, is subject to a certain law, which must be recognized before we can make any effectual progress in our investigation.

The destruction of iron depends on the grades of the road, on the tonnage, and on the travel. Every ton of freight that passes produces a certain amount of injury; every passenger car and every passenger does some injury, and every engine that traverses the line produces its share of mischief; but the number of engines that traverse the road, in conveying a given amount of tonnage, depends on the limiting gradient—and, consequently, the destruction of iron, *cæteris paribus*, is greatest on those roads of which the grades are most unfavorable to the useful effect of the power.

If we call N the number of miles travelled by all the engines on the line; T the number of tons net conveyed one mile; and P the passengers conveyed one mile, for one year, then

$$a\,N + b\,T + c\,P,$$

will be the form of the expression which represents the amount of injury which the iron has sustained—a, b, and c, being constants to be supplied by

experiment. It is assumed, of course, that the weight and form of the rail, as well as the weight, construction, and velocity of the engines, are uniform.

The point, now, is to determine the values of the coefficients, a, b, and c. For this purpose I take, in the first place, a road on which engines are not used, and but few passengers are conveyed. The wear of iron on such a road gives us the value of b, or the injury done by the tonnage.

There are two works of this description of which we can find published reports, and which have been long enough in activity to destroy a portion, or the whole, of their iron.

The *Chesterfield railroad*, in Virginia, constructed with a flat bar, and using horse power and light cars, has required, for some years past, about $200 per mile for new iron, to replace that which is destroyed by the passage of an average trade of about 50,000 tons of coal. The destruction is here equivalent to *four mills* per ton per mile.

The *Mine Hill and Schuylkill Haven railroad* was originally constructed with a flat bar, and six miles in length of the road had been renewed with a heavy edge rail, before 400,000 tons had passed along it. Assuming the value of the flat bar at $60 per ton, or $1200 per mile, which is below its present value, and that the iron was worn out by 400,000 tons, the result will be three mills per ton per mile. But this road is provided with a double track, and the track which was destroyed was not used by the ascending cars.

The injury produced by the empty cars is certainly more than one-third of that effected by those which are loaded; and the result on this road, therefore, corresponds very closely with the previous example. The wear then obviously will not be less than four mills on a road sustaining locomotive power—where the velocity is much greater than on the Chesterfield and Mine Hill roads.

I will not, therefore, be above the mark in assuming $b = .4$ mills.

The flat bar on the *Petersburg road* may be considered to have been worn out in six years, by use which was equivalent to 12,000 trips of locomotive engines; 130,000 tons of freight, and 100,000 passengers carried over each mile. If we consider the injury caused by cars carrying five passengers, equal to that produced by those carrying one ton of freight, and the value of this iron equal to $1200 per mile, we shall have

$$b\,\mathrm{P} + c\,\mathrm{T} = \$600$$

for the damage due to the freight and passengers.

The remaining sum of $600 is the destruction produced by the 12,000 miles run by the locomotive engines; whence we have

$$a = \frac{60,000}{12,000} = 5 \text{ cents};$$

or five cents for the injury done by the passage of the locomotive engine over every mile of the road.

We obtain, then, from this procedure, $a=5$ cents; $b=4$ mills; and $c=\frac{4}{5}$ mill, and for our formula

$$\frac{5\,\mathrm{N}}{100}+\frac{4\,\mathrm{T}}{1000}+\frac{4\,\mathrm{P}}{5000}.$$

If these values be correct they will apply to any other similar case.

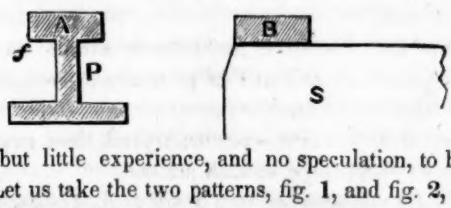
The first iron used on the South Carolina road, was destroyed in less than six years—after it had borne about 130,000 through tons, and 120,000 through passengers, and the locomotive engines had made 10,000 through trips. The formula will give for this case,

$$\frac{10{,}000\times 5}{100}+\frac{130{,}000\times 4}{1000}+\frac{120{,}000\times\frac{4}{5}}{1000}=\$1{,}116$$

for the destruction of the iron per mile. This is, no doubt, very near, the true value of the first iron used on that road, estimated at the present prices.

There are several other roads, of both descriptions, for which similar computations might be made, and which would confirm the estimate—and I shall take occasion, at a subsequent period, to present much data of the same character in a tabular form. But without discussing this branch of the subject further, at present, it may be stated in round numbers, that the average destruction of the half inch plate rail, caused by engines, freight, and passengers, is equal to about 8 *mills per ton net per mile;* and by comparing the above expression of the wear of the rail, with that previously obtained for the wear of the cars and engines, we will perceive that they possess very nearly the same value—or that the injury done to this iron, by the passage of a train, is but about 10 per cent. less than the wear and tear of the engine and cars composing the train.

In the application of this formula, however, the fact is not to be overlooked, that it is derived from the destruction of the plate rail, and is intended only to be applied to that description of road. *The destruction of any form of* T *or* H *rail, which I have yet seen, will be greater.* It is true that the expenses of maintenance for some new roads, provided with heavy iron, are yet very light, and they will possibly continue to be light until they have carried from three to five hundred thousand tons of freight —when, if the rail is still in existence, they will be very heavy.



It requires but little experience, and no speculation, to bring us to this conclusion. Let us take the two patterns, fig. 1, and fig. 2, for the purpose of illustration. Fig. 1, is a common form of edge rail, of 60 pounds per yard, of which the head, or upper table, A, weighs 20 pounds. Fig. 2, is a common plate rail, $2\frac{1}{2}$ inches wide, by $\frac{7}{8}$ of an inch thick, which also weighs about 20 pounds.

This flat bar is supported along its whole length and breadth by the

wooden string, S, and the edge rail is supported only in the centre by the vertical stem, P. Is there now any reason why the unsupported flanch, *f*, should do more service than the supported flat bar, B? The vertical stem and base of fig. 1 never wear out; it is the head of that rail which is crushed and rolled to pieces. When the rail is destroyed the lower portions are untouched; but when the head is bruised and split, the whole rail is rendered useless—and when the rail is ruined, 60 pounds of iron per yard, are lost to the company. The flat bar will bear just as much—indeed, being supported, a little more—hammering, and when it is destroyed, but twenty pounds are lost. Besides it may be welded when broken, the ends may be "upset," and restored when split; new holes, when necessary, may be punched, and it can be returned to the road until the lamination and splintering throughout render it wholly unfit for useful service.

But it is not my intention to speculate here on the relative merits of rails. The present object is to adduce facts and conclusions based on observation of many roads of various descriptions, in relation to the destruction of such rails as are ordinarily adopted. I know that my opinions on this head are not those of the public, nor of many professional gentlemen of much experience; but I believe they are, nevertheless, correct, and I therefore submit them to a test which will speedily be applied, and by which this question will be most conclusively settled.

The rails of the Reading road are, by common consent, acknowledged to be good; the pattern is considered, by the advocates of edge rails, to be unexceptionable; and the mode of manufacture adopted—that of making the lamina horizontal—is considered to render them almost proof against wear.

In regard to these rails—with all their merits, and all their superiority—I affirm,

1st. That they will not withstand the rolling of the trade of the Schuylkill for one year.

2nd. That before 800,000 tons of coal have passed down and the empty cars have been returned on them, the present track will be entirely unfit for safe usage.

3rd. That it will cost from 50 to 75 cents to replace the iron which is destroyed by each ton of coal that descends from Pottsville to Richmond, on the present track. And,

4th. That before next August, if the company succeed in obtaining the trade which they desire, this rail will be pronounced *too light* by the very parties who now think it will last forever.

The fault, however, is less in this particular rail than in *iron*, which is not tough enough for such usage, at such prices.

I know that the *Providence road* will be adduced as evidence against me, where the road has been some six years in use, and the iron is yet sound; but the Providence road actually passes but 30,000 tons per annum on a single track, and must yet stand 25 years before it can do one year's business of the Schuylkill canal.

The *Georgia road* may, perhaps, be quoted as evidence, where *experience*, they say, has demonstrated, beyond all question, the ability of railroads to compete with canals for the conveyance of heavy freight; but the Georgia road has been less than three years in operation, and has *not yet carried as much freight as has sometimes passed along the Schuylkill canal in three days!* Pour the trade of the Schuylkill, or Erie canal on parts of that road, with such engines as would be needed for its conveyance, and the track would be crushed in less than four weeks.

The *Boston and Lowell road* will be quoted. This road has not yet carried, in the eight years of its existence, an aggregate tonnage equal to the annual Schuylkill trade—and that tonnage has been sufficient for the destruction of the first track of edge rail, and the company are now, and have been for some time, using the second and third tracks.*

The *Camden and Amboy road* was originally provided with a "permanent" track. The aggregate trade has not yet reached 300,000 tons net—the reader who feels any interest in such matters can cross the Delaware to Camden, and examine the old rails, and form his own conclusions; he will then be able to judge whether these have given out because they are too weak, or because the material, in this form, is inadequate to a much greater effort.

In *England*, however, it is contended, people have more experience. The *best* experience there, is that of the Liverpool and Manchester railroad, a work which was opened to public use in the fall of 1830. This road was at first supplied with two tracks of edge rails, weighing 35 pounds per yard. The rail answered very well until the fall of 1833, when the work had passed about 300,000 tons on each track, at which period £150 were expended for *new rails.* In the next half year, before they had transported 350,000 tons, an aditional outlay of 3,000 pounds Sterling was required for new rails, and the adopted pattern was pronounced *too light* for the service. A rail weighing 50 pounds per yard was next tried, and subsequent experience showed that that also was *too light.* A new pattern was then projected, weighing 62 pounds per yard, and forthwith submitted to the same rough usage. The trade on this road is great, and soon tests the merit of fancy. This pattern was also found inadequate, and another, weighing 70 pounds per yard, was fixed upon, which was, *last year*, regarded as the pattern rail. I have not yet heard how it wears, but one year more will test its strength on that road, where there is really a heavy trade, although the net tonnage does not reach one-half, nor much exceed one-third of the average trade of the Schuylkill, or Erie canals. I do not believe that either pattern would resist the action of one year's business of one of those works, if it were confined to a single track.

I trust that those who have made observations on this interesting subject, will communicate them for publication in this Journal. If there be an edge

* It is proper to say that the rails of this road were taken up after six years' use, because they were too weak; but we never meet with rails that are strong enough after they have sustained the passage of 600,000 tons.

rail in the United States, which has sustained the passage of a million of tons of freight,* conveyed by locomotive engines, it could not but be regarded as a most encouraging circumstance, and its history ought to be known; such a rail—weighing 60 pounds per yard—would show the practicability of reducing the average cost of this item, for such rails, down to 6 mills per ton per mile; and, therefore, below any result which I have yet been able to obtain. My impression is, from the comparisons of the actual destruction which I have been able to make, that its value may be reduced, by the adoption of a suitable flat bar, and a moderate speed, to 3½, or 4, mills per ton per mile.

(To be continued.)

NOTES ON PRACTICAL ENGINEERING.—NO. 3.

Railway Curves.

There are two modes of running curves in general use here; by chords and by tangents. In Col. Long's manual, published many years since, the method of chords is adopted; in Mr. Van De Graaff's work a system of rectangular co-ordinate axes is used in connection with the method by chords; in Mr. Mifflin's treatise a geometrical process is adopted, the auxiliary curves being actually traced on the ground and the curve itself traced by the mode of chords; in Mr. Johnson's tables the system of tangents is adopted and the offsets to hundredths of a foot calculated for tangents of from 25 to 200 feet in length, increasing by 25 feet; the angles of deflection and lengths of arcs are also given for tangents of 100, 150 and 200 feet. The offsets are the parts of the secant included between the tangent and the curve, and the angles which they form with the tangents are also calculated. In the "Civil Engineer and Architect's Journal" of 1840 there are very extensive tables of ordinates from tangents from ½ to 5 chains, calculated to the nearest tenth of a foot, but the deflections are not given as the chain alone is used.

Opinions differ as to the value of the different methods. Where the tangents are run out on the ground, a variety of curves may be laid off with great ease from the same tangents, and this is frequently desirable where the ground is so difficult as to require a pretty close approximation to the best line even for a preliminary survey. The following table is taken from the "Civil Engineer's Journal" and, as the use of the Transit is general here, the deflections for tangents of 500 feet have been calculated, so that in its present form it may be often useful to the American engineer.

Table for setting out Curves by Ordinates from Tangents with the angles of Deflection for Tangents of 500 feet.

Radii in feet.	Tangents in feet.										Angles of deflection
	50	100	150	200	250	300	350	400	450	500	° ′
500	2·5	10·1	23·0	41·7	67·0	100·0	142·2	200·0	282·1	500·0	90 00
6 "	2·1	8·4	19·1	34·3	54·6	80·4	112·7	152·8	203·1	268·4	79 37
7 "	1·8	7·2	16·3	29·2	46·2	67·5	93·8	125·5	163·8	211·0	71 04
8 "	1·6	6·3	14·2	25·4	40·1	58·4	80·6	107·2	138·6	175·4	64 00
9 "	1·4	5·6	12·6	22·5	35·4	51·5	70·8	93·8	120·6	151·7	58 06
10 "	1·2	5·0	11·3	20·2	31·8	46·1	63·3	83·5	107·0	134·0	53 08

* In a report on Heron's cast iron rails laid before the committee of Science and Art of the Franklin Institute, about two years ago, I stated that no road in the United States had yet sustained one million of tons of freight. I have not yet heard of such an instance.

Radii in feet.	Tangents in feet.										Angles of deflection
	50	100	150	200	250	300	350	400	450	500	° ′
1100	1·1	4·6	10·3	18·3	28·8	41·7	57·2	75·3	96·3	120·2	48 53
12 "	1·0	4·2	9·5	16·8	26·3	38·1	52·2	68·6	87·6	109·1	45 14
13 "	1·0	3·9	8·7	15·5	24·3	35·1	48·0	63·1	80·4	100·0	42 04
14 "	·9	3·6	8·1	14·4	22·5	32·5	44·5	58·4	74·3	92·3	39 18
15 "	·8	3·3	7·5	13·4	21·0	30·3	41·4	54·3	69·1	85·8	36 52
16 "	·8	3·1	7·1	12·6	19·7	28·4	38·7	50·8	64·6	80·1	34 42
17 "	·7	2·9	6·7	11·8	18·5	26·7	36·4	47·7	60·7	75·2	32 47
18 "	·7	2·8	6·3	11·2	17·4	25·2	34·4	45·0	57·2	70·8	31 03
19 "	·7	2·6	5·9	10·5	16·5	23·8	32·5	42·6	54·1	67·0	29 29
20 "	·6	2·5	5·6	10·0	15·7	22·6	30·9	40·4	51·3	63·5	28 04
2100	·6	2·4	5·4	9·5	14·9	21·5	29·4	38·4	48·8	60·4	26 47
22 "	·6	2·3	5·1	9·1	14·2	20·5	28·0	36·7	46·5	57·6	25 39
23 "	·5	2·2	4·9	8·7	13·6	19·6	26·8	35·1	44·4	55·0	24 32
24 "	·5	2·1	4·7	8·3	13·0	18·8	25·7	33·6	42·6	52·7	23 32
25 "	·5	2·0	4·5	8·0	12·5	18·1	24·6	32·2	40·9	50·5	22 38
26 "	·5	1·9	4·3	7·7	12·0	17·4	23·7	31·0	39·3	48·5	21 46
27 "	·5	1·9	4·2	7·4	11·6	16·7	22·8	29·8	37·8	46·7	20 59
28 "	·4	1·8	4·0	7·2	11·2	16·1	22·0	28·7	36·4	45·0	20 14
29 "	·4	1·7	3·9	6·9	10·8	15·5	21·2	27·7	35·1	43·4	19 34
30 "	·4	1·7	3·8	6·7	10·4	15·0	20·5	26·8	33·9	42·0	18 56
3100	·4	1·6	3·6	6·5	10·1	14·5	19·8	25·9	32·8	40·6	18 20
32 "	·4	1·6	3·5	6·3	9·8	14·1	19·2	25·1	31·8	39·3	17 46
33 "	·4	1·5	3·4	6·1	9·5	13·7	18·6	24·4	30·8	38·1	17 14
34 "	·4	1·5	3·3	5·9	9·2	13·3	18·1	23·6	29·9	37·0	16 44
35 "	·4	1·5	3·2	5·7	8·9	12·9	17·6	22·9	29·1	35·9	16 16
36 "	·3	1·4	3·1	5·6	8·6	12·5	17·1	22·3	28·3	34·9	15 59
37 "	·3	1·4	3·0	5·4	8·4	11·1	16·6	21·7	27·5	33·9	15 23
38 "	·3	1·3	3·0	5·3	8·2	11·8	16·2	21·1	26·8	33·0	14 59
39 "	·3	1·3	2·9	5·1	8·0	11·5	15·7	20·6	26·1	32·2	14 37
40 "	·3	1·3	2·8	5·0	7·8	11·3	15·3	20·1	25·4	31·4	14 15
4100	·3	1·2	2·7	4·9	7·6	11·0	15·0	19·6	24·8	30·6	13 53
42 "	·3	1·2	2·7	4·8	7·4	10·7	14·6	19·1	24·2	29·9	13 37
43 "	·3	1·2	2·6	4·7	7·3	10·4	14·3	18·6	23·6	29·2	13 16
44 "	·3	1·1	2·6	4·6	7·1	10·2	14·0	18·2	23·1	28·5	12 58
45 "	·3	1·1	2·5	4·4	7·0	10·0	13·7	17·8	22·6	27·9	12 41
46 "	·3	1·1	2·4	4·3	6·8	9·8	13·4	17·4	22·1	27·3	12 23
47 "	·3	1·1	2·4	4·2	6·7	9·6	13·1	17·0	21·6	26·7	12 09
48 "	·3	1·0	2·3	4·1	6·5	9·4	12·8	16·7	21·2	26·1	11 54
49 "	·3	1·0	2·3	4·1	6·4	9·2	12·5	16·3	20·8	25·6	11 39
50 "	·3	1·0	2·2	4·0	6·3	9·0	12·3	16·0	20·4	25·1	11 25
5500	·2	·9	2·0	3·6	5·7	8·2	11·1	14·6	18·5	22·8	10 23
60 "	·2	·8	1·9	3·3	5·2	7·5	10·2	13·4	17·0	20·9	9 31
65 "	·2	·8	1·7	3·1	4·8	6·9	9·4	12·3	15·5	19·3	8 47
70 "	·2	·7	1·6	2·9	4·5	6·4	8·8	11·4	14·4	17·9	8 10
75 "	·2	·7	1·5	2·7	4·2	6·0	8·2	10·7	13·4	16·7	7 37
80 "	·2	·6	1·4	2·5	3·9	5·6	7·7	10·0	12·7	15·6	7 09

W. R. C.

THE ERIE CANAL—ITS CAPACITY—LOCKAGES—IRON BOATS.

We were among many who, in 1834–5, were deluded into the belief, after the completion of our present lateral canals, of the necessity of procuring enlarged avenues for the trade beyond our own State, at that period the capacities of railways to convey freight was not fully developed. We adopted and advocated the plan of a large, or "steamboat canal," 8 feet by 90 feet, from lake Ontario to the Hudson, with locks, 30 feet by 130 feet. The plan was to take advantage of the natural waters of the Oswego river, the Oneida river and lake, and from thence by Rome on the north side of the Mohawk river, to the Hudson. The length of this canal was 92 miles to Utica, and from thence to the Hudson 107 miles, total 199 miles of canal, showing a difference of canal, of 213 miles to be constructed, in favor of the Oswego route, compared with the Buffalo route. The natural waters of lake Ontario and Niagara river, 160 miles.

So feasible was the project, and limited the expense, from Oswego to Utica, owing to the use of the rivers Oswego and Oneida, and lake Oneida, 57 miles, the estimated cost was only $1,131,898, demonstrated by actual surveys. Five and a quarter millions were allowed as the cost of the canal to the Hudson Such was its feasibility, that the canal interest became alarmed for the diversion of the western trade by a cheaper channel, and in a reckless manner, rushed into the enlargement of the Erie canal, without regard to party or to its cost. It was truly a *sectional* movement, made without sufficient surveys and examinations, and we are disposed to exonerate the engineers for their estimates, as they candidly said in their report, they had not time to make the necessary surveys. Warnings of the difficulties, and statements, that the estimates were inadequate, were treated with derision. We well recollect being told by the chairman on canals, in 1835, "The policy of the State is decided on, we cannot entertain the subject of seperate canal from lake Ontario, and the use of the Welland canal, or, a ship canal around Niagara Falls, let their merits be what they may, we must enlarge the Erie canal." In consequence, a bill was introduced, *mhich passed without remark ! !* giving the canal board full powers to make the canal of any size, pledging the whole treasures of the State to this stupendous undertaking. It was pointed out to the canal committee "that the tonnage of the upper lakes was than actually let down into the lake Ontario, by the Welland canal; that the vessels could be transferred from the lakes to the sea-board, by the improvement proposed, in the fall, to return with loads in the spring; that our fresh water sailors, instead of spending six months in idleness, could be transferred with their vessel to the seaboard, and have employment the entire year; that our lake vessels were particularly adapted, from their construction and light draught of water, to our West India and southern country trade; that 140 miles of canal navigation and tolls would be saved; further, that by the plan proposed we should have two canals, and competition instead of one, and this too for one-third the sum $27,000,000, we then stated (in face of the calculation of $12,400,000)

it would take to enlarge the Erie canal to Buffalo; that by the plan we proposed, we should avoid the interruptions and damages incident, as has proved to be the case of the enlargement; that, to a great extent, we should have to make a new canal in all the difficult places, to enable us to construct the locks, culverts, aqueducts, etc., in the summer."

The "bubble age" with the canal mania of the day has, however, passed, and the truth should be told. It is now well recollected, that both parties had to elect their candidate for the presidency. "The Young Lion of the West," and the majorities beyond Cayuga bridge were to be courted. The project of a separate large canal, from lake Ontario to the Hudson, being frustrated by timid politicians, without a fair arguing into its merits, led us to examine into the necessity and extravagance of making a ship canal out of the Erie canal for the trade of our own State, a canal that only required to be bottomed out, and double locks constructed to Syracuse, this side of the main lateral canals. We discovered this was everything that we wanted for the trade and commerce of our own State, and for the trade beyond us, the Oswego route could defy competition.

We opposed the enlargement from principle; we had not a dollar involved in the question. To ascertain the necessity of the enlargement, we were led to examine, in 1835, into the number of lockages at Alexander's lock, west of Schenectady—the test lock for the business on the canal. We found the average was only one every 12 minutes, during the season of navigation—that in this time the lockages could be trebled. To arrive at the nature of the trade on the canals, the present comptroller, Mr. A. C. Flagg had the goodness to adopt the suggestion, to class the tonnage floated on our canals, under the following heads:

The produce of the *forest*, of *agriculture*, of *manufactures*, of *merchandize*, and of other articles. The tables of 1836 compared with subsequent years, led to the discovery that the produce of the forest which in 1836 was 755,252 tons of the 1,310,807 the whole number of tons that floated on all our canals, fell off in 1842 to 504,597 tons, of the 1,236,931 tons that during that year floated on our canals. During this period, the increase of tonnage from agriculture, and from all other articles, did not make up the decrease of lumber, although the tolls were greatly increased, from the fact, that the tons produced from agriculture, paid four times the tolls paid on the produce of the forest.

The obstinacy with which the enlargement was persisted in, without adequate surveys and estimates, led us to expose the folly of the same. This occurred in 1836, 1837, particularly, after the extension of the Mohawk and Hudson railroad to Utica, and the construction of other railways in this country and Europe, began to develope the capacity of this, truly styled "*better improvement of the age*," to convey freight, as well as passengers at all seasons of the year; and this too, at rates to defy competition on this line by the Erie canal, if properly constructed and located.

We well recollect that such was the mania for canals, that we were laugh-

ed at for our folly in advocating such doctrines, and were considered by many who had not investigated the subject, as fit for a straight jacket. We well recollect stating six years ago, that the Erie canal was not up to one-third of its capacity. This deduction was drawn from the experience of the lockages at Alexander's lock, on the greatest days of business in 1835-6. We then stated "*that further expenditure beyond clearing out the present canal to four feet and making double locks and pond reaches to Syracuse was unnecessary.*" That such was the improvements then making in the paddle gates—and the case was instanced on the Lehigh canal of their passing a boat through a lift of 32 feet in 2½ minutes, while ours were only 8 feet—that from this fact, there could be no question of the capacity of the Erie canal, when improved as pointed out, and releived of its packet, and semi packet boats of emigrants and their baggage, that it would answer the wants of this State for all time to come. That if the western States were to be accommodated, as they should be, and the State to hold the toll gate, the Ontario route should be adopted, as the cheapest.

This conclusion was drawn from the fact, that our lockages in 1835 and 1841, the years of the greatest business did not exceed 12 minutes to a lockage, on an average. We stated, "that there would be no difficulty from past experience, in passing 55,000 or more lockages, instead of 25,998, the number passed in 1835." This number was reduced in 1842 to 22,869 with a continued falling off this year, so as not to exceed on an average, a boat, every sixteen minutes.

Holding these views, and in corroboration of the same, we were gratified to perceive in a late report of Mr. Little, the canal commissioner to the deputy comptroller, Mr. G. W. Newell, that on the 11th inst. at Fultonville, and under all the disadvantages of the cold weather, and as he states "considerable ice in the canal, and snow falling several inches," that 92 lockages were accomplished in 7 hours and 15 minutes being in the ratio of one for every 4⅔ minutes for an 8 feet lift. This is not to be compared with the celerity of lockage on the Lehigh, and on other canals, although there is no doubt but that the ice and snow greatly impeded the operation, or it could have been done in less time.

The above ratio of 4⅔ minutes, would give for the season 71,500 lockages, being more than three times the number of lockages this season, with a large increase of tolls, and capacity of the boats.

With facts of this kind, and yet another, that instead of the capacity of the canal, up to 1841 to float boats drawing 2 feet and 11 inches of water, with a load of only 30 to 40 tons, such is the improvement in the canal, by *bottoming it out* and in the construction of the boats and by the adoption of the iron boats, (which we advocated in your Journal for several years,) that we have now repeated instances of boats loading 60 to 83 tons, drawing three feet of water, the latter load being an iron boat, with Ericsson's propellers. We venture, therefore, little in predicting, that 80 tons to above it, when 3 feet 6 inches water can be obtained, will be the common load for the iron

ooat, and further, that the distance from the Hudson to Buffalo, will be accomplished by steam, in one-third the time, now performed by horses, thus again trebling the capacity of the canal.

It should be taken into consideration, that our business has heretofore been performed by single locks. Now we have double locks to Utica, the most crowded part of the canal, and east of all the lateral canals.

We will close with the remark, often repeated, let the railways parallel to the Erie canal have the privilege to carry freight the entire year, even burthened with tolls, or like the New York and Erie railroad, be free to compete with the canal, and our word for it, we may suspend the enlargement for a long period, if not entirely, and save full $20,000,000 in its prosecution. This will certainly be the case if we include the interest that is lost ere the canal is used during its entire length.

J. E. B.

For the American Railroad Journal and Mechanics' Magazine.

REMARKS ON MR. ELLET'S FORMULA FOR COST OF TRANSPORTATION ON RAILWAYS.

In your November number, there is an article under this caption, by Mr. Charles Ellet, Civil Engineer, who therein lays down certain *fixed laws*, which he further terms simple principles such as cannot well be doubted or denied. Against the validity of these laws we beg to offer some remarks, leaving it to your intelligent readers to decide between us.

1st. Mr. Ellet's law on motive power.

"The cost of motive power with engines of the same class is proportional to the distance which the engines run. The cost per mile is nearly the same on all roads of all grades, the difference in expense on roads with different grades consists not essentially in variations of the cost per mile run, but in variations of the number of miles which must be performed to do the same duty."

Remarks.—The reader should first have some idea of the several items composing the cost of motive power and the proportions which each item bears to the whole expense, which for an example we will state as follows:

Wages of engineman and fireman,	per annum,	$1150	25 pr ct.
Fuel,	"	2000	44 "
Oil, etc.,	"	350	7 "
Repairs of engine,	"	1000	24 "
Total cost of running an engine doing full work, pr an.,		$4500	

Scarcely one of the above items can be called strictly constant, the wages even, which are the most so, will differ with the locality and degrees of skill of the men employed. The fuel, nearly half of the whole cost, is widely different; the price in Georgia is $1 per cord, and 3 and $4 per cord in the middle and northern States, and the *quantity used* depends on the velocity and amount of load, etc. The repairs of engines, these are affected by the quality of the machine itself, of the road it runs upon, the velocity and the skill and care of the driver. Scarcely any two roads are alike in the qual-

ity of their engines. Some are made to run 35,000 miles per annum, and others will hardly perform a third of that work; a fair average of annual work for one engine is from 18,000 to 20,000 miles which she will do at a cost per mile run, varying with the circumstances here enumerated; this variation being as much as 16 to 33 cents per mile or about 100 per cent. The comparative cost of transportation on railways will thus to some extent be affected by the difference in expense *per mile run*, but the real test of their *comparative economy* is at last determined by the *amount of business or load* which is found for every mile which must *necessarily* be run on the respective lines, the disproportion in the miles thus run and the loads carried therewith on different roads, being in general very considerable, whether of passengers or freight, but which, while the expense of running is constant, will be ever changing favorably with the progressive increase in business commonly attendant on the stimulus from railways, and is finally limited only by the power of the engines on the particular grades of the road, the facility of overcoming which, has been of late greatly increased, and thereby the economy of railways. We offer the following instances in exemplification of these positions: thus on the

	Grades	Cost to run an engine per an.	Amt. of net load pr trip.	Total tons per annm.	Cost per ton.	Miles run	Cost pr. mile run
Baltimore & Ohio,	84 ft.	$4500	20	2500	$1 80	20000	22½ c.
Georgia road,	37	3300	40	5000	66	20000	16½
Reading road,	level	4000	160	18000	22	20000	20

The variations are here seen to be scarcely any in the cost of the miles run, but widely so in that of the *duty performed*, going to show that the want of *adequate and regular business* is the real root of all the evils of a railway, and as this business grows upon it, so does it improve in general consolidation and in profitableness. Every one of the roads cited above have improved in both these particulars *with age*, and particularly the first. The Reading road not yet fairly mounted, with as yet *but one foot* in the stirrup, is perhaps the only one using steam in this country, which in *freight* is so lucky as to be worked full up to the capacity of its machinery and grades, and to have both the one and the other of the most favorable kind for profitable transportation, the cost *per ton carried* and *per mile run* being here nearly one and the same, while on most other roads it is *widely* different and the waste immense. Being a practicable thing, we shall soon expect to see the further economy practised on the Reading road, of making the *tonnage carried* at least equal *if not greater* than the *miles run*, that is, an engine running 188 miles should be of the capacity to deliver at least 250 tons.

2d. Mr. Ellet's law on repairs of road.

"The repairs of road, with equal trade, are proportional to its length, that is, cæteris paribus it costs twice as much to keep up a road 200 miles long as it does to maintain one in the same condition of which the length is 100 miles; just as it costs twice as much to run engines 200,000 miles as it would to run the same class of engines 100,000 miles."

Remarks.—It is right to state that the repairs of road are proportionate to its length, that is a *mileage* charge; it consists of two items, the renewal of materials composing the road and the labor of making those renewals and in keeping the track level, the drains free and all other work about the *road bed*, both items will of course be very various on different roads; the one, in the *first cost* of the materials and their exposure to decay on the particular line of road; the other as it may have a firm foundation, easy drainage, freedom from deep cuts, etc. The experience, however, of now some 12 to 15 years applied to efficient roads adequately constructed, enables us to say that the several items of sills, bridges, iron, etc., may be entirely *renewed* by an appropriation of per mile per annum, $300

The important item of labor, the principal source of the after economy of railways, if liberally bestowed, may differ widely, but to do all the work generally required on a fully employed road an annual expenditure per mile will be necessary, of about 350

$650

per mile or $65,000 per annum for 100 miles, as the maximum for *this kind of road*, which will vibrate yearly, but not exceed that sum at its climacteric point of age, which is made up of the average duration of each of its materials, towards and from which point it will be ever either approaching or receding. The common error is to suppose that the *whole* first cost of a road is *again* to be incurred at the end of a certain time, without adverting to the fact that these annual appropriations or intermediate outlays had provided against this contingency, *as necessary*, to insure both safe and profitable transportation over it. That neglect occasionally occurs in this and other respects, as the result of poverty, is certainly true, but where this principle of always keeping the road and machinery up to the *standard of new*, is faithfully attended to, there can be no distinction of old and new roads as made by Mr. Ellet, except as we have already stated, the latter should be *all the better* for their years.

The illustration in the latter part of this law of Mr. Ellet's for road repairs, leads to the inference that they are in proportion to the business done on them; this is not entirely so, the item for renewal of materials may with the increase of business be slightly increased, but that for labor in upholding track, etc., should be nearly as good for 500,000 as for 100,000 tons; and its economy will tell favorably just as the business of a road is large or small; as in the Reading road in the year 1843, the estimate for maintenance and repairs of road is $45,000, which on its tonnage for this year of 250,000, will be 18 cents per ton, while in 1844 with the tonnage doubled, the same item at $50,000 per annum, will not exceed 10 cents per ton. The wear of most of the materials of a railway are now well ascertained, the iron or the principal one, being that about which there is most speculation, enough however is known to establish the fact when the article is good in quality and adequate in weight, that its duration is such, as to make its renewal compassable, after a deduction for the old iron, by a very small annu-

al appropriation; and we are assured that the iron founders derive but *little custom* in England from the annual wear of the iron rails, even there, where the velocity is seldom less than 30 miles with travel and 15 miles per hour with freight. The maximum for the latter in this country is now fixed at about 10 miles per hour. Railways, hardly yet out of the experimental stage, have been gradually working up, in their structure and machinery to the point of adequacy to the duty required of them—more than that would be waste—although the fault here had better be rather a little too much than too little. Till tately the road had to do everything for the locomotive, now there is a reciprocation of favors between them, and the latter can adapt itself to almost any strength of structure with increased power instead of losing any of it. This may well be termed a *compound stride*, in this new, useful and indispensable system of conveyance.

3d. Mr. Ellet's law for repairs of cars.

"The repairs of cars are proportionate to the number of tons conveyed and to the distance to which they are conveyed. It costs twice as much to repair cars which run two millions of miles as it does those which run one million of miles per annum. Again, it costs twice as much to repair cars which convey 20,000 tons as it does those which convey 10,000 tons a given distance. The same principle applies equally to the conveyance of passengers; it applies also to accidents, incidentals and contingencies, for these increase with and are proportional to the increase of business."

Remarks.—The repairs of a car whether passenger or freight, will of course be in some proportion to the work it does, that is, under equal circumstances and quality of article. Tha car itself and the treatment of a car is very different on one road and another, arising principally in the character of the road itself, if a flat bar or an edge railroad, its proper adjustment, and the use more or less of breaks as required by the undulations of the road, these twist a car and subject it oftener to jerks and concussions, and then the expense of attendance; on some roads the breaks may require one man to every three cars, on others one man to every twenty five; his wages of $300 per annum are in one case $100 per car, in the other only $12, this, however, has nothing to do with the repairs, but shows one of the expenses of heavy grades.

We find in England pasenger cars doing full work are repaired at a cost of 5 to 6 per cent. per annum on their cost, and in this country with roads generally inferior, 6 to 8 per cent.; freight cars doing rougher work but at a less speed are renewed from 10 to 15 per cent. on the cost, against all casualties and giving them full employment. The reasonableness of this charge will appear when it is considered of what a car is composed and the value about it to be renewed. Let us take a Reading coal car, these at present cash cost of the items, have $120 of iron and $40 of wood on them, or $160 in all. Iron castings which formerly were 5 to 6 cents per lb. are now 2¾ cents per lb. from which the old material at 1 cent per lb. would remain to be deducted; the wooden portion of this kind of car is now turned

out very cheaply by machinery. Here, then, is but a trifling value of the most perishable part of it to replace. Say this car delivers 300 tons per annum, which at 8 cents per ton, the estimate of the superintendant of the Reading road for repairs, is $24 per annum, or just 15 per cent. on the value, and this is to include all casualties as the damage from *mere running over the road* is scarcely an appreciable item. A double track now in preparation by this road will result in much economy on this item, and it is accordingly expected to be reduced on that event and other developments in management, which come only with time and experience. That accidents are necessarily proportional to the increase of business on roads is not in accordance with either the practice of this country or England, a large business always affording the more means and increasing the skill, for their avoidance.

These remarks in their specific application, will, we trust, for the sake of railways present and to come, do something towards overturning these laws of Mr. Ellet, but in order the more fully to do this, we here give his "formula," of which these laws are the basis, and compare it with the actual results on the Baltimore and Ohio railway, as given with much distinctness of detail in their recent report for 1843, a feature much to be commended and which we like to see practised in future by all railways of any note, seeing the good that it has done the cause in this instance.

FORMULA.

	For new roads under 4 years old.	For old roads over 4 years old.
For repairs of road, for every mile of road,	$300 pr mile.	$500 pr mile.
For every ton conveyed one mile,	9 mills	14 mills
For every passenger carried one mile,	7 "	7 "
For evey mile travelled by the engines,	24 cents.	27½ cents.

RESULT ON THE BALTIMORE AND OHIO RAILWAY IN 1843.

The report gives 509,000 miles as travelled by the engines at a cost of, $95,936
The formula for old roads is 27½ cents per mile, 137,430—41,494
or a variance from actual practice of 43 per cent. on this item.
The report states the freight trains to have carried a tonnage equal to 7,034,310 tons carried one mile for, (or 4 mills per ton,) $28,381
The formula gives a mean cost for old roads of 14 mills, 98,480—70,099
or a variance from actual practice of 240 per cent on this item.
The report states the repairs and maintenance of road for 178 miles, at per annum $100,000
The formula gives a mean for old roads of $500 pr mile, 89,000—11,000
or a variance from actual practice of 12 per cent. on this item.

What annihilation is here, in this "formula" of itself, to the railway system, but lest this should not be enough, he has a "corps de reserve" in freshets, tornadoes, and incendiaries, under the name of "extraordinary expenses" not included in the formula, which, according to him, will finish what

the "formula" may have spared. But Mr. Ellet has deceived himself by the confidence he has so innocently placed in railway reports which are in general notorious for their indistinctness of detail and otherwise inconclusive character for any such purpose as *just* comparisons. In this way he has been led into the mistake of calculating against the *well established rule* with railways, that their expenses are in an inverse ratio to their business—that is, the latter being large, the former will be comparatively small. Moreover, and finally, laws of this character to be good for anything should be uniform and invariable; the railway therefore, if these properties belong to Mr. Ellet's laws, should be *stationary*, instead of which, it has been and still is *most progressive* in the character of both its own structure and its appurtenant machinery, as evinced in the recent and last improvement by Baldwin and Whitney, in the locomotive, so truly termed the *main spring* of this system, and by which the light flat bar road has been saved from condemnation. The most of our railways have been sickly only from insufficient business, and it would be unfortunate indeed, could Mr. Ellet establish that *full work* the panacea to which they look confidently for recovery will be their certain death; a fate which all good men should deprecate, in the case of works so beneficial in their effects. F.

For the American Railroad Journal and Mechanics' Magazine.

NOTE TO ARTICLE ON "CANALS OF CANADA."

(See Railroad Journal for November, 1842.)

Important events which have occurred during the last year, require notice, in order fully to comprehend the "prospects" of these canals on so gigantic a scale. Their failure was based on the absence of that general information and high character which are to the projection what mechanical skill is to the execution of a work. The latter is necessary to the assistant—to the engineer who aspires to success both are indispensable. The earth work and masonry of canals are well understood by the American engineers and their Canadian assistants under whose superintendance these canals are placed; and it can scarcely be doubted, that they will be respectably executed. But no excellence of workmanship can compensate for radical defects in the projection.

It was observed (page 258,) that

"That portion of the western trade which seeks a foreign market via the St. Lawrence, is attracted by political rather than natural or engineering advantages, and, to this extent, does not come within the province of this Journal."

Still it may be observed that the present Canadian and British duties are 4*s.* per quarter of wheat or 12 cents per bushel, in place of the old sliding scale of from 1 to 5*s.* per quarter, which had averaged 2*s.* or 6 cents per bushel. The western trade has been very heavy this year, but the trade of the St. Lawrence has not increased. This is owing more to the losses under the old system than to the slightly increased disadvantages of the new tariff.

The locks of the Welland canal have been increased to 150 feet in length, the better to accommodate the "propellers," a class of vessels the writer ventured to predict, (Journal, April, 1842,) could scarcely fail to come into gen-

eral use. This was done principally on account of the representations of forwarders from Oswego, who have derived much and will derive still greater benefit from the Welland canal. Indeed this work may be considered rather American than Canadian, and this feature will gradually increase, rendering the canal ultimately able to support itself.

Speaking of the down trabe it was said, (page 259,)

"The down trade is by the river, about 200 miles, barges and small steamers running direct from Kingston to Montreal. The draft of water is limited by the depth of the "Cedars," where, at lowest water, a vessel cannot pass, drawing more than 4 feet, to 4 feet 2 inches. It must be observed that nothing has ever been done to improve the down trade of the St. Lawrence, and, the writer believes, that a sum not exceeding £20,000 cy. would give 5 feet water at lowest water in the Cedars, besides less important improvements, such as removing boulders, placing buoys, etc., at other places."

During the last summer, a new and deep channel has been discovered in these rapids. This is a most important and remarkable discovery, leaving little to be desired as far as the down trade is concerned. The almost certainty of the existence of such a channel was pointed out to the writer in September 1842, by Mr. McPherson Jur., a member of the principal forwarding house in the Province—while descending the "Cedars" in the steamer "Juno," Capt. Marshall, who was the first to show its practicability. Had this been achieved by the Board of Works it would have been considered, and not without reason, as entitling them to the lasting gratitude of the country; the press would have been unable sufficiently to commend their merits, and even the thinking few, who see the inevitable result, would have been forced to confess, that this happy discovery would do much towards compensating the immense and permanent injury inflicted by the Board on the Province.

It can scarcely be considered an exaggeration to say, that this channel has been found in spite of the Board who had utterly neglected and in fact discouraged every attempt to aid the improvement of the rapids. Thus, so late as 10th Oct. 1842 it was pronounced by he chairman of the Board, Mr. H. H. Killaly, as "a dangerous navigation requiring the expensive protection of insurance," though this was only three-eighths of one per cent. or not quite 2 cents per barrel of flour from Kingston to Montreal through the *old* channel of the Cedars where losses were principally sustained. Yet this trifling charge was more than sufficient to cover the risk even *then*, and Messrs. McPherson, Crane & Co. were their own insurers.

As remarked in the article to which this *note* refers, "the down trade is indeed the only *great* consideration;" yet was the chairman of the Board an "engineer of great experience and scientific acquirements," ignorant of the risk attending the downward navigation of the St. Lawrence which is of course accurately measured by the rates of insurance based on the experience of many years. This element is indispensable in projecting a canal which is to supersede the use of the river for down freight. The very first point which would have arrested the attention of an engineer acquainted with the western trade and not "a stranger to the country" is, obviously the downward navigation of the St. Lawrence; yet the forwarders of Canada,

unlike their more fortunate brethren of Oswego, failed in drawing the attention of the Board to their representations of the vast benefits which a very slight expenditure might effect in the navigation of the rapids, more especially in the "cedars." The Board appear to have entirely overlooked "the part of Hamlet," till the new channel at last made even *them* understand that the down trade must go by the river. It is scarcely necessary to observe that this had been long known to every one else at all acquainted with the trade and navigation of the St. Lawrence.

The enlargement of the Lachine canal, the locks of which are now 20 by 100, will give the "coup de grace" to the only successful canal the Province has owned or will own till the Welland canal shall clear expenses and interest; a period many years distant. Upwards of 60 tons have been repeatedly carried on the Erie canal, less than 4 feet deep, with wooden boats. An iron steamer took 83 tons of freight from Albany to Oswego passing through locks 15 by 90. Boats filling locks 100 by 20 and drawing 6 feet water will be about equal to boats filling the locks of the enlarged Erie canal will which are 100 by 18, though they are decidedly superior in proportions to the latter. Since the "Cedars" no longer limit the draft these boats can always descend the St. Lawrence, and the present facilities of the down trade by the river—without any cost beyond part of the trifling amount of insurance—are more than equal to the utmost advantages anticipated from the enlargement of the Erie canal, to be executed—if ever—at an enormous cost and not to be attended with any *reduction* of tolls, though inflicting a direct tax on the State of $600,000 per annum.

The St. Lawrence canals depend therefore on the up freight and this was at last admitted by the chairman of the Board in parliament. Now the absolute amount and rate of increase of the western trade are well known, and the probability of the small portion of that trade, going via the St. Lawrence, increasing to an amount sufficient to pay the interest on four millions of dollars from the tolls on 36 miles of canals, besides repairs and superintendance, is too remote to have any interest for the present generation.

Judging from the dilatory proceedings of the Board in completing the Chambly and Cornwall canals (as far as canals in that climate may be considered to be completed without protection wall on the inner slopes) the writer does not believe they could in any circumstances fulfil their promises as to time; judging from the actual cost of works in Canada he does not believe the Province has the means of completing these short canals; and judging from this determination to enlarge the Lachine canal he does not believe the Province will, at the end of ten years, be able to point to a single successful work. In the case of the Lachine canal they are literally carrying out the views of Dean Swift's philosopher, whose highest ambition it was to confer on his country a race of sheep without any wool.

The expenditure of large sums in different parts of the Province necessarily gives a certain degree of popularity to the Board, and the promises which are made as to the early completion of the St. Lawrence canals plea-

se those who believe they will increase the trade of the country. It is therefore the time when the views of the writer are least likely to find favor in Canada; consequently the period the most honorable to bring them forward. They remain as given a year since in this Journal.

It would be difficult to find a more brilliant proof of the immeasurable superiority of private enterprise over governmental attempts. The latter with immense expenditures accomplish nothing useful and will be remembered only by the taxes imposed to pay the debt—the former present freely to the public a vast benefit, which their own common sense had led them to suppose attainable, and which their own skill, energy and resources had triumphantly demonstrated to be so.

New York, Nov., 1843. W. R. Casey.

For the American Railroad Journal and Mechanics' Magazine.

CROTON WATER PIPES BURSTING.

Since the previous article was written, (see number for October) I have tried a series of experiments on the subject; being desirous to arrive at a just conclusion, which results were as follows:

When the faucet was as large as the pipe to which it was attached and full open at the discharge, there was no pressure at the end of the faucet acting to burst the pipe, except the friction of the water in its passage; this shows that if the pipe is burst (which it is) by suddenly shutting off the water alone.

I also tried in my series of experiments on this subject, shutting off the current of water at about 40 feet from the end of the pipe, which end was the discharge, this produced about the result or jar in the pipe beyond the faucet, though by a different mode, as if shut off in the ordinary way with a pipe 40 feet long, this pipe I tried both straight and with a number of bends, or serpentine in form, the straight pipe had but one jar or "blow," on shutting off the water, but the bent or serpentine form had as many jars or "blows" in the pipe as there were bends; these were caused in this way, the impetus of the water in the straight pipe, beyond the cock was in motion after the faucet was shut, which still proceeded as long as the impetus so given lasted, forming a vacuum between the stop-cock and the end of the water in the pipe, which returned with a "blow" which was the "water hammer," whose operation was the same as explained in the before mentioned article; when the pipe was bent the blow or jar was less heavy on each part, but amounting to the same in the aggregate, the blow nearest the cock was the heaviest, and they decreased gradually at each bend or turn according to length of each junction, towards the end of the pipe, all striking successively on the return of the water.

Glass pipes have been proposed and tried in Europe for conducting water but have not been applied here, to the writer's knowledge; from some experiments on glass I am of the opinion, that from it being almost non-elastic it could not be applied where stopping the water would jar or strike it, as it

breaks very easy under such circumstances, but will stand an enormous dead pressure.

Glass varies much in its strength under different circumstances, as the least change by heat or cold *unequally* applied will weaken it much and if extended sufficiently will break it. It is true iron is affected in the same way, after repeated, unequal, very high heating, and then cooling, as we see by gas retorts, stoves, etc., after use.

History relates an invention by which glass was made that could not be broken; this cost the inventor his life, by being thrown off the scaffold from which his glass was dashed but did not break; we want such glass for Croton water pipes.

Many a man's invention in these times, costs him *his life*, or *its equivalent, his all.* You will hear from me again on some other subject soon.

New York, Nov., 1843. CIVIL ENGINEER.

ACCIDENTS UPON RAILROADS.

Messrs. Editors.—The reader was made acquainted in our last number with the regulations in *England* excluding cattle from railroads, and with the safety to which those regulations had contributed. How long are we to wait for the adoption of similar regulations here, where they are more needed, the mischief being more imminent? The triumphs of human genius over the elements are daily advancing the march of civilization, and adding to the comforts of the human race; and though it might be presumptuous to doubt that the power of steam has been given to us for ultimate good, it may well be questioned whether the public authorities are warranted in sending forth an agent of such tremendous effect without adequate safeguards. The application of this new power on water and on land is the great invention of the age.

Railroads, and the speed of which they are susceptible, have become as indispensable to all classes of our population as any of the old modes of locomotion, and the convenience and interests of the public will neither admit of abandoning the one nor reducing the other. Therefore, if from collisions arising from obstructions upon the road, these improvements are not only to lose much of their utility, but be made eminently dangerous in their operations, it becomes the duty of the legislature to take the subject into its hands, and, following the lights of experience, apply the same remedies here that have been found both indispensable and effectual elsewhere.

That degree of safety which by possibility can be attained by the most judicious management upon the part of railroad companies, and by the utmost care and caution of their agents, ought to be first insured; but if experience prove these inadequate, the obligation to provide further safeguards becomes not less imperative. To accomplish the first there certainly has been no want of rigor in those who make the laws. Towards the railroad companies and their agents the penal code of Maryland is marked by the utmost severity. Although the operations of their roads yield little or no profit, railroad companies are required to spare no expense in keeping their works in thorough repair; to provide the best and most approved system of machinery, and adopt every proper improvement which the effort of genius may suggest, even under the heavy exactions of their inventors, and to employ the fullest complement of agents of competent skill; and from all persons in any way engaged in the operations of the works the utmost care and

caution which the highest capacity can insure is rigorously enforced. Not only so; but here, in this State, the wise, humane rule of the common law, which presumes innocence until guilt be proved—the great shield interposed by justice against wrong and oppression—is completely inverted. In the case of injury to person or property, arising from an accident on a railroad in Maryland, the law directs the civil magistrate to take it for granted, without any proof whatever, that the casualty happened from the fault of the company or its agents! To presume that an engineman has carelessly thrown the sparks from his engine into a neighboring barn, or heedlessly, and at the risk of his own safety, run his engine into an animal on the track, and to punish him accordingly—unless, by some other testimony than his own, which from the nature of the case is seldom at hand—he should be able to prove that the accident was unavoidable. We think the reader will not only pronounce this to be in all conscience enough, but will be apt to consider it an inversion of all the rules of deduction from evidence, by which we usually form a judgment of human conduct. In my view it would require only a small spice of injustice or prejudice in the magistrate who is called to execute the law, to assimilate it to the iron rule of the despot of Prussia, which doomed a soldier to be shot, if, while on parade, his hat should be blown off by the wind.

Let it be conceded, however, that this degree of severity is, under the circumstances, necessary, and therefore justifiable. Why is it necessary and justifiable? Surely the public authorities do not mean to treat those who have, at a heavy expenditure of capital, introduced these new works and adapted them to the wants of the public, as guilty of improper conduct, and therefore objects of vindictive justice! In sanctioning their enterprizes, the legislature sent them forth as the projectors of beneficial improvements, themselves the objects of the countenance and protection of the law. Bound, no doubt, to exert their utmost care to prevent injury to others from the dangers incident to their enterprize; but entitled, in common with the public, to be guarded against hazards, produced by the wantonness or carelessness of others, which no care of theirs could avoid.

It is to be supposed that the legislature is under no obligation to afford the public other security against accidents on railroads than the imposition of penalties upon those managing them? To say to the survivors, in case of death, or to the man who may have lost his limbs or his property, look for remuneration to the railroad company? Money, severe as the penalty may be upon the company, does not always afford adequate remuneration for such injuries; it seldom mends a limb; it never restores life; and in the majority of cases can make no atonement whatever for its loss. What the public want, and what the nature of the case demands, is *preventive* measures; those which *preserve* persons and property from injury, rather than such as leave them exposed to loss, and attempt, after it is suffered, to make compensation for it.

On no other ground can the penalties, already adverted to, against the railroad companies and their agents be excused, and much less justified. They are designed, and in this respect entitled to commendation, to exert the force of the penal power to insure the utmost care and skill and providence upon the part of the companies to guard against mischief, and thereby afford all the security which in this way can be given—nothing more. The grievances, or omission, or whatever else it may be called, as we think, is, that the legislature seem to have proceeded upon the idea that the railroad travelling was exposed to no other risks or danger than those which might arise from the negligence of the companies or their agents, or that these could ac-

complish impossibilities; and have thereby left the most ordinary source of danger unguarded. Let the case be supposed, that an animal, emerging from its concealment by the side of the road, suddenly comes upon the track, within ten yards of the locomotive, attached to a train of four or five cars, containing more than one hundred passengers, and proceeding at the rate of twenty or fifteen miles per hour; at twenty miles, the engine would run the ten yards in a single *second* and at fifteen *in a second and a quarter!* In a second and a quarter of time, it would be manifestly impossible to let off the steam, reverse the engine, and apply the breaks—much more to stop the train! The collision takes place and limbs are broken or lives lost. Under such circumstances, if any one should be unreasonable enough to bring suit the magistrate who might be selected to examine the case, whoever he might be, if not grossly corrupt, would find himself compelled to exonerate the railroad company and the agents. If he did otherwise, he would afford no security against the recurrence of a similar casualty. Now, then, here is a danger, and one of almost daily occurrence, against which neither the company nor the public have any security whatever. It may be observed, moreover, that in the case supposed, the result would not have been different, as it respects the collision, if the animal had been *fifty* instead of *ten* yards in front of the engine.

Now, if there be only a single class of obstructions, and that of frequent occurrence, which it is impossible for the railroad agents by any care on their part to avoid, against that the public have the right to demand the requisite protection. We have been able to conceive of no other likely to be effectual than an explicit law making it the duty of all to *clear the track.*

But there are more than one class of obstructions equally perilous, to which we may refer in another number.—*Balt. American.* T.

Messrs. Editors.—We have already spoken of the speed of railroad travelling, and of its importance to the public. In the further investigation of the subject, however, we think that this part of it ought at no time to be lost sight of. In truth, the capacity to transport the greatest weights, at the least cost and highest velocity, constitutes the chief object of the improvement. It is this which has enabled it to supersede at once the ordinary modes of conveyance—has impressed its influence upon the present age, and is destined to produce even more wonderful effects in the future. While on the water, the power of steam has diminished the size of our rivers, and contracted the ocean itself to less than half its breadth, the same agent on the land has leveled the loftiest mountains, and gone far to annihilate those distances which previously separated the various parts of our continent. In this country the effects, social, moral and political, are not to be overrated. While most of the other nations of the globe are reaping the benefits of the centralization resulting from the power of steam on water and on land, we could not if we would, creep along at the old fashioned pace; but when we come to contemplate the consequences of bringing all parts of this vast empire within a few day's journey, and of uniting their population in one great family, we will be apt to desire rather to augment than diminish the power of the locomotive.

Now, the cheap transportation of the greatest weights at the utmost attainable velocity, is to be produced, under the lights of science and the guidance of experience, by the power itself; but that degree of safety which is to give the grand result, must be looked for to the interposition of the lawmakers; and we repeat that the measures adopted for this purpose should have reference to the nature of the improvement, and to the character of the risks. They should be applied with enlarged views and bold hands. If

we mean to master the elements and render them subservient to our daily wants, we must do it effectually—we must suffer no stale usages, or unreasonable privileges to stand in our way, or weaken our dominion.

Bearing these considerations in mind, let us pursue the tenor of our remarks. It appears, by the report of Mr. Stevenson, that in 1838 the average speed of railroad travelling in *England* was thirty miles an hour; which, in the communications attached to the appendix to the report of the Irish railway commissioners, was regarded as a mere *starting point.* Able commentators upon that report confidently anticipate, from improvements in the railway and machinery, a speed of from 60 to 100 miles an hour, and of such rate predicate the ultimate advantages to be expected from the introduction of railroads. In the same year, as appears from the same report, upon railroads in the United States, at that time comprehending a distance of 1600 miles, the average speed was stated at fifteen miles an hour. Since that period the extent of railways in the United States has not only been considerably increased, amounting at present to not less than 3,000 miles, but we have acquired the means of a greatly accelerated velocity. In numerous instances, too, they have been adopted as post roads, and it may be safely assumed, from this cause, that the competition among railroads, that upon all the principal lines, and especially those employed in the transportation of the mail, the average speed is not less than twenty miles per hour; and to attain that aggregate velocity upon a long line of road, the train upon many parts of it must proceed at a still greater speed. In the reports to the English parliament, to which we have already more than once referred, it is estimated that at a speed of thirty miles an hour, a train cannot be stopped in less than two hundred yards; and in our first paper we ventured to assert that in this country, at a speed of twenty miles, a train could not be stopped in less distance than one hundred and fifty yards. Whether we are right or wrong the reader may, with a slight examination, entirely satisfy himself.

An engine and train, at the rate of twenty miles an hour, may be stated to run six hundred yards in a minute, ten yards in a second, and one hundred and fifty yards in fifteen seconds, or one quarter of a minute. To stop a train it is required not only to shut off the steam, but to reverse the motion of the engine, and apply the breaks of the cars; and for these purposes, ten seconds may be stated as the least possible time. But during these ten seconds the engine will have run one hundred yards, according to all experience, a heavy train at the rate of twenty miles an hour, under circumstances the most favorable to resistance, will continue its motion, though doubtless somewhat reduced, for at least ten second more. If its velocity should be reduced one half, it would require the whole space we have supposed.

It is to be observed, moreover, that the space in which a train may be stopped, is dependant not only upon the weight and speed of the train, but the grade of the road, and often varies from one-eighth to a quarter of a mile. We have been present at an experiment made under the most favorable circumstances, with a train not exceeding the usual weight, and proceeding at a speed of less than twenty miles an hour; and we saw it very clearly demonstrated that with the readiest application of the appliances, such a train could not be stopped in less than one hundred and fifty yards. If the fact be at all doubtful, the legislature have it in their power—and in a case of so much importance it is surely their duty—to ascertain its truths. In the mean time we will proceed upon the hypothesis now proved.

It is clear, then, that if obstructions be found upon the track of a railway at a less distance than one hundred and fifty yards from the engine, no degree of care nor skill nor power upon the part of those in charge of the train

can, by possibility, prevent a collision. When the reader reflects upon the frequent occurrence of obstructions from cattle on the road within even a less distance, he cannot fail to require that some further security should be provided against the consequences to which they too surely lead.

We profess to be somewhat familiar with the operations of railroads. Our attention has been often drawn to the subject, and we have sought information in regard to it from all sources within our reach. We have, too, frequently had occasion to examine particularly into the circumstances attending casualties of almost daily occurrence; not only to detect, and if found, to punish negligence, but to discover any possible means by which a recurrence of the evil could be avoided.

Of the numerous accidents arising from cattle found upon the track, we are not aware of a single instance in which the collision has happened when it was possible to discover the animal within one hundred and fifty yards of the train. On those roads with which we are more particularly acquainted, we may state positively that no such instance has occurred. Indeed, it may be affirmed, that such collisions most frequently occur where the obstruction is found within a distance varying from ten to fifty yards than at any other; and in all the cases that have come under our observation the persons in charge of the train have freely risked their own lives to prevent harm to those exposed in the cars. Although the public on such occasions are apt to think only of the safety of the passengers, overlooking the fatal injuries often inflicted upon the humbler parties, we confess we have come, after much observation, to give a wider range to our sympathies; and to include within them those agents hourly, and in case of collision, inevitably exposed to disasters, which in a moment, may reduce their families to want. We have come to regard the conductors, and enginemen, and firemen of the trains as we do the adventurous sailor, who exposes himself in all weathers and risks his life upon the frailest spar or the slenderest rope to preserve the comfort and safety of the inmates of the ship; and we think that in legislating upon this subject, no humane statesman would overlook the protection justly due to such men. Now, as far as our experience goes, collision with cattle found upon the tracks of railroads may be said invariably to arise in one of the following cases:

1. Where the animal is found at night lying between the rails, and, in most instances, not discovered until actually entangled in the train.

2. Where the animal suddenly comes upon the track at night, or in the day time, from the bushes on the side of the road, and within a short distance from the locomotive.

3. Where, being on the track, but hidden from the view of the engineman by a curvature in the road, cannot be seen at a sufficient distance to enable him to avoid the collision.

These risks, it will be seen, afford ample room and space for fearful injury to life and limb, *against which, the law, as it now stands, makes not the slightest provision.*

In another paper we may refer more particularly to the most serious accidents which have arisen under one or all of the heads above stated.—*Baltimore American.* T.

ADVANTAGES OF THE FORM OF RAIL AND STRUCTURE OF THE PHILADELPHIA AND POTTSVILLE RAILROAD.

In designing the parts of a new work, it is the duty of a skilful engineer to study the peculiar circumstances of the case, and proceeding from known laws and well ascertained facts to produce such a plan as can with certainty

be predicted to answer the desired end. In most cases, the trial of direct experiment, under all the given circumstances, is quite out of the question, particularly when *time* enters as an element into the calculation. All that can be done therefore is to make use of such experiments, or rather, of such experience as shall approach nearest to the case in point. In applying these principles to construction in general, and in particular to railroad construction, it is evident that there must be wide room for the display of that sort of discretion which mainly contributes to the formation of professional skill. When time has confirmed the predictions of the engineer, the case may fairly be quoted as experience in future works—and the careful examination this experience of works constructed upon our own soil, and therefore adapted to our peculiar wants, will in course of time form the most valuable part of professional information. It is therefore the duty of every one to present either the result of his own labors, or his observation on those of others, to contribute to the common stock of knowledge.

A period of four years having elapsed since the completion of the Philadelphia and Reading railroad, with a heavy traffic for the greater part of that time, we feel enabled to speak with some confidence as to the merits of the mode of structure employed upon that work. No description in our own words could be more full or accurate than that given by Messrs. Knight and Latrobe, in their celebrated report on the forms of rail and superstructure in the United States. This description, it will be seen, was written before the completion of the work; we have however allowed the first paragraph to stand, as identifying the time, and as showing that it contains no after thoughts.

PHILADELPHIA AND READING RAILROAD.

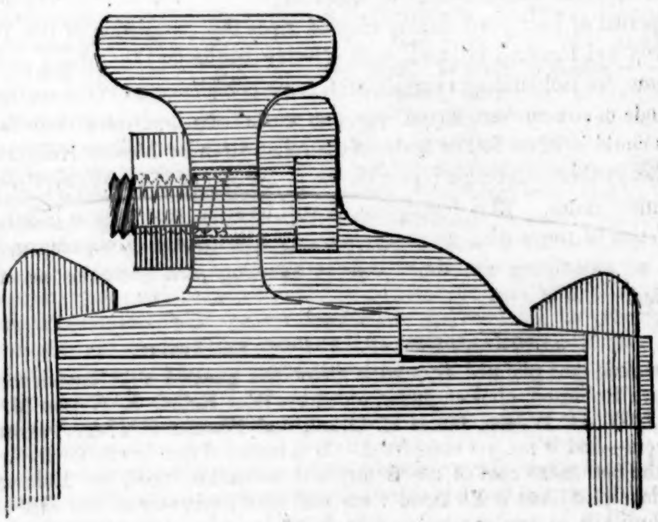
This road was planned by, and is under the general superintendence of Moncure Robinson, civil engineer, aided by Wirt Robinson, Wilson M. C. Fairfax, W. H. Wilson, James H. Grant, and Thomas P. Huger, assistant engineers—and is not yet completed. It is intended principally for the transit of the anthracite coal of the Schuylkill to market, upon the Delaware, at Philadelphia, and will extend from the coal region down the valley of the Schuylkill, at grades varying from a level to descents of 19 feet per mile in a direction from the mines, with the exception of the pass from the Schuylkill to the Delaware, where an ascending line from the former river to the summit of the divide, of 40 to 50 feet to the mile, will be admitted, upon which assistant locomotive power will be employed.

Plan of construction.—The H rail is employed, weighing $45\frac{1}{8}$ lbs. per yard lineal; each bar is $18\frac{3}{4}$ feet in length, with square ends, and weighs, on an average, 282 lbs., or 8 bars to the ton. With exception of the square ends, the form of the rail resembles that on the Washington branch of the Baltimore and Ohio railroad, except that is $5\frac{1}{8}$ lbs. to the yard heavier than the latter.

The rail is laid upon the white oak sleepers, or cross ties, 7 feet in length and hewn upon the upper and lower sides, so as to have a flat surface for the under bearing, and a similar one for the rail to rest upon of 8 inches wide; the depth of the sleeper being 7 inches uniformly. These are laid 3 feet $1\frac{1}{2}$ inches apart from centre to centre, and cost, upon an average, delivered

at distances apart of about two miles, on the graded surface of the road, about 60 cents each. Timber is scarce and dear upon the Schuylkill, and it was said that these were brought by the Union canal from Huntingdon county. Each sleeper is laid upon a prism of broken stone, deposited in a trench 14 inches deep, 12 inches wide, and 9 feet long, transversely of the line of the track. The cost of broken stone was, on an average, (for this the first track) $1 10 per perch of 25 cubic feet, delivered in heaps 10 feet apart on the road surface. Two sizes of broken stone are used, the one to pass through a two inch, the other through a three inch ring, the larger of which constitute the lower portion of the mass. The stone were placed and compacted in three different layers, one upon the other. The spaces between the sleepers are filled with clay, or any material most convenient to be obtained. This filling reaches to the top surface of the sleepers in the middle of the track.

Every sleeper, (except where there is a chair,) is notched to a depth of about one-fourth of an inch, to receive the lower web of the rails. These notches cost 5 cents per sleeper, which is not included in the 60 cents above mentioned.



Of the *fastenings*, it may be observed, that the rails, at their joinings, rest upon cast iron chairs, let into the sleepers by means of notches cut for that purpose. The chair is 6 inches square at its lower surface, where it is five-eigthths of an inch in thickness. Upon that side of the chair situated upon the outer side of the track, and upon the entire length of the chair, there is a portion of the casting having an upward projection, and passing over the lower web of the rail upon that side, and thence to the stem of the rail; and also extending to, or very nearly to, a contact with the under side of the *upper* web. Through this upper projecting part of the chair, there are two square countersunk holes, to receive square bolts, with heads formed to fill the countersunk holes: each bolt passes through one of these holes in the chair horizontally, and likewise through a hole in the stem of the rail, near its end. The hole in the rail, however, is not precisely square, as it is in the chair, but is $\frac{3}{4}$ by $\frac{7}{8}$ of an inch, and situated at a clear distance of $\frac{3}{4}$ of an inch from the end of the rail. The hole in the chair is for a bolt $\frac{4}{8}$ square,

and the head of the bolt to fill the countersink, is $\frac{15}{16}$ square. Upon the inner side of the rails, a nut screws upon each bolt, to hold the ends of the two rails to the chair, and in proper line, while the hole in the rail is wider than the bolt to allow for contraction and expansion from change of temperature. The bolt and nut weigh 7 ounces, and the chair $10\frac{1}{2}$ lbs., and is held in place by means of 4 spikes, the heads of which pass over the edge of the chair, while their stems are driven into the sleepers, and also fill recesses left for that purpose in the corners of the chairs in casting them. The same kind and size of spike is used to fasten the rail to each sleeper, (except where the chairs are) the head of the spike passing over the edge of the lower web on each side of the rail. The spikes are 6 inches in length, and their stems are $\frac{3}{4}$ by $\frac{5}{8}$ of an inch, and they weigh about $\frac{3}{4}$ of a lb. each. It is thought that the stem should be square, and the length $4\frac{1}{2}$, or at most 5 inches.

The varied cost of the iron rails at Philadelphia, averaged about $60 per ton. And the cost of the conveyance to the road, by means of the Schuylkill navigation, was $2 60 per ton.

There are in the mile of track,

Bars of rails, in number	563,	weighing	71	tons.
Chairs,	do.	563,	do.	5,910	lbs.
Spikes,	do.	7,882,	do.	4,524	"
Screw bolts & nuts,	do.	1,126,	do.	481	"
Sleepers of wood,	do.	1,689.			

It was stated by W. M. C. Fairfax, (from whom most of these details were received,) that the track cost an average rate of $1 50 per sleeper, or $2,533 per mile, exclusive of the cost of all the iron materials, at Philadelphia.

The cost *of laying down* this single track of railway, consisting of excavating the trenches to receive the broken stone—putting down the broken stone—laying, notching, and adjusting the sleepers—putting on the chairs and the iron rails complete—*has been, on an average,* 40 *cents per sleeper,* or $675 60 per mile of track: to which W. M. C. Fairfax would add, for contingencies, such as cutting the iron bars, in order to make the joinings of each two have a position opposite to the middle of the length of the opposite rail, or bar, (this being a condition uniformly observed in the track) extra transportation, cleaning the side ditches, making crossings, etc., say about $200 per mile.

The above mentioned 40 cents per sleeper, or $675 60 per mile, is included in the aforesaid $1 50 per sleeper, or $2,533 per mile. The contracts for laying down the railway were made at so much per sleeper, viz., 40 cents, as above.

The entire cost of the single track, as laid, is stated by Moncure Robinson to be $7,617 per mile, inclusive of materials and workmanship.

We have omitted the cut of the chair and rail in plan and profile, as the minute accuracy of the above description will answer a much better purpose. The peculiarities of this system of construction are, the disuse of longitudinal timbers of any kind, the mode of fastening the rails in the chairs, and for allowing at the same time for changes in temperature.

The advantages attendant upon the longitudinal connection of the rails alone are, the saving of timber, at the time the road was built, a scarce article upon the Schuylkill; the broken stone or timber when partially decayed, with longitudinal bearers, will afford the means of passing water from a great distance so as to accumulate in such quantities as to prove dangerous

to the soundness of the road. Moreover, one more perishable article is stricken from the component parts of the road. The mode of fastening the rails from personal inspection, we nave satisfied ourselves to be excellent—the allowance for temperature being perfect, while no displacement of the rail can possibly take place. After all that can be urged in favor of the form of this rail, the best evidence of its merit is the fact that it answers the purpose for which it was intended. There are other forms which doubtless would prove equally serviceable—but this has been tried and already found excellent.

It is the duty of all who are familiar with the *superiority* or *inferiority* of any form of structure to make known their remarks upon it for the benefit of others.

By a singular mistake, our notice of Mr. Nott's advertisement was not inserted in the last number of the Journal. It will be seen that he aims mainly at private business, a source, in our opinion, sadly underrated, and as his experience and standing are unquestionable, we are happy to find him aiding the cause of the profession in the most efficient manner possible; that is, extending its usefulness by enlarging its field of operations.

IRON CANAL BOATS.

It was more than four years ago, and prior to any heavy expenditure on the enlargement of the Erie canal, that our correspondent, J. E. B., proposed the employment of iron boats on the canal. He urged on our canal board, as well as our forwarders, to build one, and to test their capacity. He argued, very naturally, that the same results would be found here, as had been experienced in England.

It is gratifying to find by the following extracts from the Miners' Journal, and from a late number of the Albany Argus, (making remarks on the "navigation of the Erie canal,") that this subject is at last claiming the consideration it merits. From inquiries made in this city, we have no doubt but iron boats, that will out last three wooden boats, can be constructed for $1600. Some of our best lake boats cost nearly this sum. The wooden boat is more subject to leake, and cause damage, arising from stones and obstructions that fall into the canals, than the iron boat. The latter are made perfectly water tight.

Iron Canal Boat.—The Miners', Pa., Journal contains a statement of the size, weight, cost, etc., of the new iron canal boat recently built at Pottsville. The light weight of the boat is 15 tons 12 cwt.; the weight of the boat and cargo was 85 tons 2 cwt., leaving a cargo of 69½ tons of coal. The boat draws 4 feet ½ inch midships, and 4 feet 1 inch at the stern—say 4 feet 1 inch draught of water. The cost of the boat is stated at about $2200. In future, iron boats can be constructed for about $1800.

From present indications there is also every probability that for the first time, next season, *iron canal boats* will be extensively introduced on the Erie canal, and as they can as easily carry 85 tons of freight as wooden ones can 70 tons, this also must have no inconsiderable influence in increasing the present *capacity* of the canal.—*Albany Argus.*

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